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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Appln. Of: OKADA et al.

Serial No.: 09/937,652

Filed: September 27, 2001

For: HYDROGEN STORAGE METAL ALLOY, METHOD FOR . . .

Group: 1746

Examiner: Bell, Bruce F.

DOCKET: SHIG C10804

MAIL STOP AMENDMENT
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

AMENDMENT A

Dear Sir:

This Amendment is being filed in response to the Official Action mailed March 15, 2004.

Please amend the Application as follows:

Amendments to the Specification begin on page 2 of this Amendment.

Amendments to the Claims begin on page 3 of this Amendment.

Amendments to the Abstract begin on page 13 of this Amendment.

Remarks/Arguments begin on page 14 of this Amendment.

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AMENDMENTS TO THE SPECIFICATION:

Please amend the paragraph bridging page 1, line 27 - page 2, line 7, as follows:

At present, there have been ~~worried~~ worries not only about acid rain due to an increasing NOx (nitrogen oxides) but also about [[the]] global warming due to an increasing CO₂ in association with an increase in consumption of fossil fuel such as petroleum and such environmental destruction has become a serious problem. Therefore, our attention has been greatly concentrated on development and practical application of various kinds of clean energy which is friendly to the earth. Part of means for developing such a new energy is a practical application of hydrogen energy. Hydrogen is a constituent element of water inexhaustibly present on the earth and can be not only produced using various kinds of primary energy but also utilized as fluid energy in place of conventionally used petroleum without the risk of destroying the environment because its product [[by]] of combustion is only water. In addition, unlike electricity, it has excellent characteristics such as its relatively easy storage.

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AMENDMENTS TO THE CLAIMS:

Please cancel claims 1, 3-5, 7, 9-13 and 17-21, without prejudice. Kindly amend claims 2, 6, and 8, as shown below. Please add new claims 23-43, as shown below.

This listing of claims will replace all prior versions and listings of claims in the Application:

Claim 1 (cancelled)

Claim 2 (currently amended): The hydrogen storage metal alloy according to claim [[1]] 23, wherein the alloy temperature (T1) during the hydrogen-absorbing process is brought to a range of from the extremely low temperature in the living areas on the earth to 373K.

Claims 3 - 5 (cancelled)

Claim 6 (currently amended): The hydrogen storage metal alloy according to claim [[3]] 1, wherein the tissue structure of the above-mentioned suitably adjusted hydrogen storage metal alloy is of a body-centered cubic structure mono phase without any spinodal decomposition phase or has a body-centered cubic structure together with only a minimum spinodal decomposition phase with is unavoidably produced.

Claim 7 (cancelled)

Claim 8 (currently amended): The method for absorbing and releasing hydrogen according to claim [[7]] 24, wherein the alloy temperature (T1) during the above hydrogen-absorbing process is within a range of from the extremely low temperature in the living areas on the earth to 373K.

Claims 9-13 (cancelled)

Claim 14 (original): A hydrogen fuel battery equipped with:

a hydrogen storage tank including a hydrogen storage metal alloy,

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a temperature controlling means whereby the above hydrogen storage metal alloy is directly heated or cooled or the atmospheric temperature of the said hydrogen storage metal alloy is raised or cooled,

a fuel battery cell in which hydrogen supplied from the said hydrogen storage tank can be subjected to a chemical change to output an electrical power, and

a controller where a control is done in such a manner that, with regard to the temperature (T1) of the above hydrogen storage metal alloy during the stage of hydrogen absorption, the temperature of the said alloy during at least one period during the release of hydrogen is made higher (T2) than the temperature (T1) thereof during the above hydrogen-absorbing process.

Claim 15 (original): The hydrogen fuel battery according to claim 14, wherein the aforementioned controller is capable of approximately controlling a pressure, temperature and flow rate of the hydrogen gas supplied from the above-mentioned hydrogen storage tank to the above-mentioned fuel battery cell.

Claim 16 (previously presented): The hydrogen fuel battery according to claim 14, wherein the above-mentioned temperature controlling means is arranged so as to enable the heat discharged from the above-mentioned fuel battery cell or the exhaust gas discharged from the said fuel battery cell to be utilized for the above-mentioned heating.

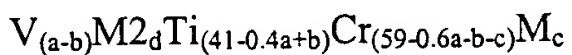
Claims 17-21 (cancelled)

Claim 22 (previously presented): The hydrogen fuel battery according to claim 15, wherein the above-mentioned temperature controlling means is arranged so as to enable the heat discharged from the above-mentioned fuel battery cell or the exhaust gas discharged from the said fuel battery cell to be utilized for the above-mentioned heating.

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Claim 23 (new): A hydrogen storage metal alloy which has as its main phase a body-centered cubic structure-type phase exerting a two-stage or inclined plateau characteristic in a hydrogen storage amount vs hydrogen pressure relation, in which the composition ratio of constituent metals for the alloy is adjusted to an appropriate range in order to reduce the stability of the hydrogen occluded in the alloy during the low-pressure plateau region or the lower plateau region of the inclined plateau such that an alloy temperature (T2) during at least a period in a hydrogen release process can be brought to higher than an alloy temperature (T1) in a hydrogen-absorption process (T2 > T1) whereby at least part of the occluded hydrogen will be made desorbable during the low-pressure plateau region in the above-mentioned two-stage plateau or the lower plateau region of the inclined plateau, wherein the hydrogen storage metal alloy is an alloy having not only a suitably adjusted composition to reduce the stability of the occluded hydrogen but also a fundamental composition of the formula:



wherein $0 \leq a \leq 70$ at%, $-10 \leq b \leq 10 + c$, $0 \leq c$, $0 \leq d \leq a$, M is at least one or more members selected from the group consisting of Nb, Mo, Ta, W, Mn, Fe, Al, B, C, Co, Cu, Ge, Ln (various lanthanoid metals), N, Ni, P and Si, and M2 is at least one or more members selected from the group consisting of Mo, Nb, Ta, W, Mn, Fe and Al.

Claim 24 (new): The hydrogen storage metal alloy according to claim 23, wherein the tissue structure of the above-mentioned suitably adjusted hydrogen storage metal alloy is of a body-centered cubic structure mono phase without any spinodal decomposition phase or has a body-centered cubic structure together with only a minimum spinodal decomposition phase which is unavoidably produced.

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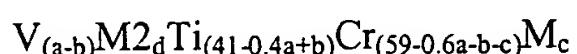
Claim 25 (new): A method for absorbing and releasing hydrogen using a hydrogen storage metal alloy which comprises:

applying repeatedly hydrogen pressurization and depressurization to the hydrogen storage metal alloy of a body-centered cubic structure-type phase exerting a two-stage or inclined plateau characteristic in a hydrogen storage amount vs hydrogen pressure relation in an appropriate fashion to absorb and release hydrogen, and

at least at one stage during the release of hydrogen, making the temperature (T2) of the above-mentioned hydrogen storage metal alloy higher than the temperature (T1) of the hydrogen storage metal alloy during the hydrogen absorption process ($T2 > T1$)

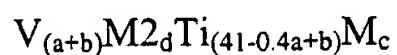
wherein the hydrogen storage metal alloy is an alloy having not only a suitably adjusted composition to reduce the stability of the occluded hydrogen but also

(1) a fundamental composition of the formula:



wherein $0 \leq a \leq 70$ at%, $-10 \leq b \leq 10 + c$, $0 \leq c$, $0 \leq d \leq a$, M is at least one or more members selected from the group consisting of Nb, Mo, Ta, W, Mn, Fe, Al, B, C, Co, Cu, Ge, Ln (various lanthanoid metals), N, Ni, P and Si, and M2 is at least one or more members selected from the group consisting of Mo, Nb, Ta, W, Mn, Fe and Al, or

(2) a fundamental composition of the formula:



wherein $0 \leq a \leq 70$ at%, $-10 \leq b \leq 10 + c$, $0 \leq c$, $0 \leq d \leq a$, M is at least one or more members selected from the group consisting of Nb, Mo, Ta, W, Mn, Fe, Al, B, C, Co, Cu, Ge,

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Ln (various lanthanoid metals), N, Ni, P and Si, and M2 is at least one or more members selected from the group consisting of Mo, Nb, Ta, W, Fe and Al.

Claim 26 (new): The method for absorbing and releasing hydrogen according to claim 25, wherein the tissue structure of the above-mentioned suitably adjusted hydrogen storage metal alloy is of a body-centered cubic structure mono phase without any spinodal decomposition phase or has a body-centered cubic structure together with only a minimum spinodal decomposition phase which is unavoidably produced.

Claim 27 (new): The method for absorbing and releasing hydrogen according to claim 25, wherein the alloy temperature (T1) during the above hydrogen-absorbing process is within a range of from the extremely low temperature in the living areas on the earth to 373K.

Claim 28 (new): The method for absorbing and releasing hydrogen according to claim 25, wherein the composition ratio of the constituent metals for the alloy is adjusted to an appropriate range in order to reduce the stability of the hydrogen occluded in the alloy during the low-pressure plateau region or the lower plateau region of the inclined plateau such that the temperature of the said alloy can be brought to the above high temperature (T2) whereby at least part of the occluded hydrogen will be made desorbable during the low-pressure plateau region in the above-mentioned two-stage plateau or the lower plateau region of the inclined plateau.

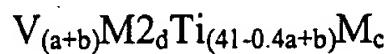
Claim 29 (new): The method for absorbing and releasing hydrogen according to claim 27, wherein the composition ratio of the constituent metals for the alloy is adjusted to an appropriate range in order to reduce the stability of the hydrogen occluded in the alloy during the low-pressure plateau region or the lower plateau region of the inclined plateau such that the temperature of the said alloy can be brought to the above high temperature (T2) whereby at

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least part of the occluded hydrogen will be made desorbable during the low-pressure plateau region in the above-mentioned two-stage plateau or the lower plateau region of the inclined plateau.

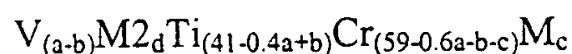
Claim 30 (new): The method for absorbing and releasing hydrogen according to claim 25, wherein the hydrogen storage metal alloy is an alloy having not only a suitably adjusted composition to reduce the stability of the occluded hydrogen but also a fundamental composition of the formula:



wherein $0 \leq a \leq 70$ at%, $-10 \leq b \leq 10 + c$, $0 \leq c$, $0 \leq d \leq a$, M is at least one or more members selected from the group consisting of Nb, Mo, Ta, W, Mn, Fe, Al, B, C, Co, Cu, Ge, Ln (various lanthanoid metals), N, Ni, P and Si, and M2 is at least one or more members selected from the group consisting of Mo, Nb, Ta, W, Fe and Al.

Claim 31 (new): The method for absorbing and releasing hydrogen according to claim 30, wherein the tissue structure of the above-mentioned suitably adjusted hydrogen storage metal alloy is of a body-centered cubic structure mono phase without any spinodal decomposition phase or has a body-centered cubic structure together with only a minimum spinodal decomposition phase which is unavoidably produced.

Claim 32 (new): The method for absorbing and releasing hydrogen according to claim 25, wherein the hydrogen storage metal alloy is an alloy having not only a suitably adjusted composition to reduce the stability of the occluded hydrogen but also a fundamental composition of the formula:



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wherein $0 \leq a \leq 70$ at%, $-10 \leq b \leq 10 + c$, $0 \leq c$, $0 \leq d \leq a$, M is at least one or more members selected from the group consisting of Nb, Mo, Ta, W, Mn, Fe, Al, B, C, Co, Cu, Ge, Ln (various lanthanoid metals), N, Ni, P and Si, and M2 is at least one or more members selected from the group consisting of Mo, Nb, Ta, W, Mn, Fe and Al.

Claim 33 (new): The method for absorbing and releasing hydrogen according to claim 32, wherein the tissue structure of the above-mentioned suitably adjusted hydrogen storage metal alloy is of a body-centered cubic structure mono phase without any spinodal decomposition phase or has a body-centered cubic structure together with only a minimum spinodal decomposition phase which is unavoidably produced.

Claim 34 (new): The hydrogen fuel battery according to claim 14, wherein the hydrogen storage metal alloy has as its main phase a body-centered cubic structure-type phase exerting a two-stage or inclined plateau characteristic in a hydrogen storage amount vs hydrogen pressure relation, in which the composition ratio of constituent metals for the alloy is adjusted to an appropriate range in order to reduce the stability of the hydrogen occluded in the alloy during the low-pressure plateau region or the lower plateau region of the inclined plateau such that an alloy temperature (T2) during at least a period in a hydrogen release process can be brought to higher than an alloy temperature (T1) in a hydrogen-absorption process ($T2 > T1$) whereby at least part of the occluded hydrogen will be made desorbable during the low-pressure plateau region in the above-mentioned two-stage plateau or the lower plateau region of the inclined plateau.

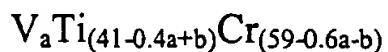
Claim 35 (new): The hydrogen fuel battery according to claim 34, wherein the alloy temperature (T1) during the hydrogen-absorbing process is brought to a range of from the extremely low temperature in the living areas on the earth to 373K.

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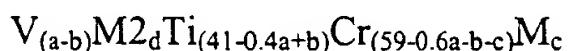
Claim 36 (new): The hydrogen fuel battery according to claim 35, wherein the hydrogen storage metal alloy is a V alloy not only having a suitably adjusted composition to reduce the stability of the occluded hydrogen but also containing 0 to 95 at% of at least one or more members selected from the group consisting of Nb, Ta, W, Mo, Ti, Cr, Mn, Fe, Al, B, Co, Cu, Ge, Ni and Si.

Claim 37 (new): The hydrogen fuel battery according to claim 36, wherein the hydrogen storage metal alloy is an alloy having not only a suitably adjusted composition to reduce the stability of the occluded hydrogen but also a fundamental composition of the formula:



wherein $0 \leq a \leq 70$ at% and $-10 \leq b \leq 10$ at%.

Claim 38 (new): The hydrogen fuel battery according to claim 36, wherein the hydrogen storage metal alloy is an alloy having not only a suitably adjusted composition to reduce the stability of the occluded hydrogen but also a fundamental composition of the formula:



wherein $0 \leq a \leq 70$ at%, $-10 \leq b \leq 10 + c$, $0 \leq c$, $0 \leq d \leq a$, M is at least one or more members selected from the group consisting of Nb, Mo, Ta, W, Mn, Fe, Al, B, C, Co, Cu, Ge, Ln (various lanthanoid metals), N, Ni, P and Si, and M2 is at least one or more members selected from the group consisting of Mo, Nb, Ta, W, Mn, Fe and Al.

Claim 39 (new): The hydrogen fuel battery according to claim 36, wherein the tissue structure of the above-mentioned suitably adjusted hydrogen storage metal alloy is of a body-centered cubic structure mono phase without any spinodal decomposition phase or has a body-centered

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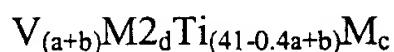
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cubic structure together with only a minimum spinodal decomposition phase which is unavoidably produced.

Claim 40 (new): The hydrogen fuel battery according to claim 37, wherein the tissue structure of the above-mentioned suitably adjusted hydrogen storage metal alloy is of a body-centered cubic structure mono phase without any spinodal decomposition phase or has a body-centered cubic structure together with only a minimum spinodal decomposition phase which is unavoidably produced.

Claim 41 (new): The hydrogen fuel battery according to claim 38, wherein the tissue structure of the above-mentioned suitably adjusted hydrogen storage metal alloy is of a body-centered cubic structure mono phase without any spinodal decomposition phase or has a body-centered cubic structure together with only a minimum spinodal decomposition phase which is unavoidably produced.

Claim 42 (new): The hydrogen fuel battery according to claim 36, wherein the hydrogen storage metal alloy is an alloy having not only a suitably adjusted composition to reduce the stability of the occluded hydrogen but also a fundamental composition of the formula:



wherein $0 \leq a \leq 70$ at%, $-10 \leq b \leq 10 + c$, $0 \leq c$, $0 \leq d \leq a$, M is at least one or more members selected from the group consisting of Nb, Mo, Ta, W, Mn, Fe, Al, B, C, Co, Cu, Ge, Ln (various lanthanoid metals), N, Ni, P and Si, and M2 is at least one or more members selected from the group consisting of Mo, Nb, Ta, W, Fe and Al.

Claim 43 (new): The hydrogen fuel battery according to claim 42, wherein the tissue structure of the above-mentioned suitably adjusted hydrogen storage metal alloy is of a body-centered cubic structure mono phase without any spinodal decomposition phase or has a body-centered

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cubic structure together with only a minimum spinodal decomposition phase which is unavoidably produced.

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AMENDMENTS TO THE ABSTRACT:

Please amend the abstract as follows:

The present invention provides a A method for absorbing and releasing hydrogen which comprises applying repeatedly hydrogen pressurization and depressurization to a hydrogen storage metal alloy of a body-centered cubic structure-type phase exerting a two-stage or inclined plateau characteristic in a hydrogen storage amount vs hydrogen pressure relation in an appropriate fashion to absorb and release hydrogen[[],]. At [[and at]] least at one stage during the release of hydrogen, ~~making~~ the temperature (T2) of the above-mentioned hydrogen storage metal alloy is made higher than the temperature (T1) of the hydrogen storage metal alloy during the hydrogen absorption process (T2 > T1)[[],]. This thereby enabling enables the release and utilization of occluded hydrogen at a low-pressure plateau region or an inclined plateau lower region, ~~which has not been utilized in the prior art. Refer to FIG. 16.~~

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REMARKS

The indicated allowance of claims 14-16 is noted, with thanks. Also noted with thanks is the indicated allowability over the art of claims 5, 12-16 and 20-22. While it is believed that the art rejection is not well founded, in order to expedite prosecution and allowance of the subject application, Applicants have amended the claims essentially to incorporate the allowed claims and subject matter indicated to be allowable by the Examiner as follows:

New claim 23 comprises in large part to claim 5 re-written in independent form. New claim 25 essentially comprises claim 12 re-written in independent form. Claim 26 essentially comprises the subject matter of claim 13. New claim 24 has been added to further scope claim 23, while new claims 27-33 have been added to further scope claim 25. And, new claims 34-43 have been added to further scope claim 20.

Since the presented claims essentially comprise claims allowed or indicated to be allowable or new claims dependent on claims allowed or indicated to be allowable, it is believed no specific discussion of the art rejection is necessary.

Having dealt with all the objections raised by the Examiner, the Application is believed to be in order for allowance. Early and favorable action are respectfully requested.

Form PTO-2038 in the amount of \$54.00 is enclosed for added claim fees.

In the event there are any fee deficiencies or additional fees are payable, please charge them (or credit any overpayment) to our Deposit Account Number 08-1391.

Respectfully submitted,



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By S. S. B.

NPS:sb

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